Integrating Uncertainty in the Semantic Web Stack

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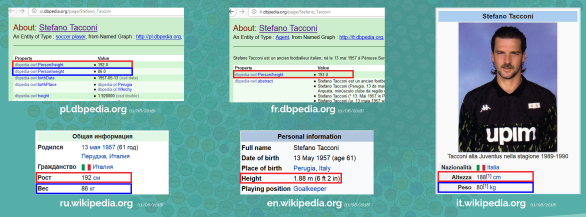
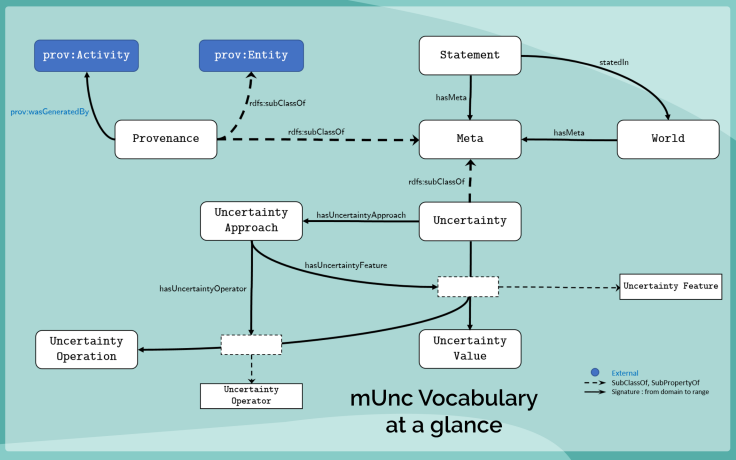
Problem

- **Uncertainty** is a common problem in any open world, and the Web makes no exception.
- A single data source (ex. Wikipedia) may contain **contradictory** information.
- Current Semantic Web standards allow the **existence of invalid, incomplete** or, in general, **uncertain data**.
- No standard representation of uncertainty.
- Data may not be linked to a **context** which allows different interpretations to one information.



Uncertainty Representation



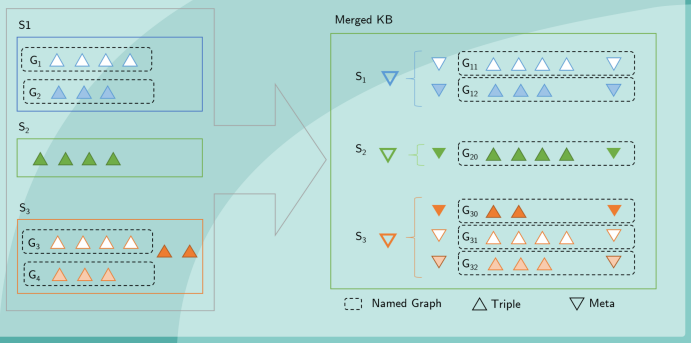
- Several approaches for uncertainty representation, (probability, possibility, evidence theory, etc.) and several features (metrics, measurements, etc) to consider.
- A set of operations is linked to each uncertainty feature.

```
@prefix ex:   <http://example.org/> .
@prefix munc: <http://ns.inria.fr/metauncertainty/v1#> .

ex:Possibility a munc:UncertaintyApproach;
               munc:hasUncertaintyFeature ex:validity, ex:completeness.
               munc:hasUncertaintyOperator ex:and, ex:or, ex:not.

ex:validity rdfs:subPropertyOf munc:uncertaintyFeature;
            rdf:range xsd:decimal;
            ex:and ex:minPossibilityFun;
            ex:or ex:maxPossibilityFun;
            ex:not ex:negPossibilityFun;.

ex:and rdfs:subPropertyOf munc:uncertaintyOperator.
```

```
ex:G1 { ex:Apple ex:hasColor ex:Red }
ex:G2 { ex:Apple ex:hasColor ex:Green.
        ex:Apple ex:hasColor ex:Blue }
ex:G1 munc:hasMeta [
 a munc:Uncertainty ;
 munc:hasUncertaintyApproach ex:Possibility ;
 ex:validity 1; ex:completeness 0.2].

ex:G2 munc:hasMeta [
 a munc:Uncertainty ;
 munc:hasUncertaintyApproach ex:Possibility ;
 ex:validity 0.8; ex:completeness 0.5].
```

Multi-level Granularity

Our approach provides a representation for different levels of granularity : triple, graph, dataset. The metadata are mapped to the triples after being evaluated.



In a few words...

The current Semantic Web standards allow the existence of incomplete, invalid or more generally, uncertain data. This work introduces a framework to handle uncertainty in the Semantic Web: uncertainty representation, reasoning over uncertain data, belief revision and propagation.

Use cases

- class-matching, ontology-alignment,
- fuzzy knowledge representation,
- reasoning over distributed uncertain linked data,
- fact-checking,
- information and data fusion.

```
prefix munc:   <http://ns.inria.fr/metauncertainty/v1>
prefix ex:     <http://example.org/>

select ?g ?s ?o ?meta where {
    {
        graph ?g {
            ?st a rdf:Statement
            ?st rdf:subject ?s
            ?st rdf:predicate ex:isSupervisorOf
            ?st rdf:object ?o
            ?st munc:hasMeta ?Tm
        }
    } UNION {
        graph ?g {
            ?s ex:isSupervisorOf ?o
        }
    }
    ?g munc:hasMeta ?Gm
    bind(ex:metaList(?Tm,?Gm) as ?meta)
}

function ex:metaList(?Tm,?Gm) {
    // Evaluate the metadata to associate with each and every triple
    // that matches the graph pattern
```

SPARQL Extension to write less complex queries

```
@metadata
SELECT ?g ?s ?o
WHERE {
    graph ?g{?s ex:isSupervisorOf ?o}
}
```

Our goal

1. **Uncertainty Representation**
   A generic model for representing the different uncertainty approaches : mUnc vocabulary
2. **Provenance Integration**
   Integrate PROV-O to represent provenance metadata
3. **Reasoning over Uncertain Linked Data**
   Display the most suitable result for the user, based on his preferences and uncertainty values
4. **Belief Revision**
   Update the knowledge base depending on the selected information in the reasoning process
5. **Belief Propagation**
   Propagate the revised information through the links towards the distributed knowledge base